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SURVEYING AND MAPPING PRACTICES FOR USE IN UNDER-DEVELOPED COUNTRIES

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SURVEYING AND MAPPING PRACTICES FOR USE IN UNDER-DEVELOPED COUNTRIES

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1. INTRODUCTION:

Most emerging nations are now undergoing a phase of rapid development. Older nations have seen the need to investigate possibilities of further economic expansion. In places with scarcity of natural resources emphasis is being place on refinery processes and chemical industries. In many parts of Africa, however, the natural resources available would for a long time provide most of the needs and reserves for the inhabitants.

1 (a) Whether or nct the exploitation of natural resources and urban development would take the proper pace depends upon the type of maps and cartographic services available. Investigation and exploration costs can be so high, and the task so long and tedious, that investors may often shrink from a lucrative venture, and the countries' economy be thereby retarded. Yet with adequate maps and modern cartographic facilities every information can be brought to the investor in so short a time and at a cost so low as to encourage investments that otherwise might have been postponed for several decades. Investigation made in the United States of America have shown that having topographic material available can reduce planning costs by seventy (70%) percent. The records give us a number of clear examples and reports underlying these experiences. For example, an industrial area in the State of North Carolina lost ten million ($10,000,000) dollars because new industries preferred to settle elsewhere owing to the lack of maps with contour lines. According to another American source, the importance of maps was clearly demcnstrated in planning a highway sixteen (16) miles long. Five thousand ($5,000) dollars were spent on three local surveys and then the costs were estimated in the usual manner. Before starting the construction work, a topographic map was produced at the price of two thousand two hundred ($2,200) dollars. By use of this map a new road-bed was chosen, and as a result, the construction costs for the highway diminished by two hundred thousand ($200,000) dollars as compared with the original estimate. In another case a railroad company economised eighty-five thousand ($85,000) dollars, by changing the planned road-bed of a railroad track after studying a topographic map. These figures are supplied by the Cooperative Society for Geodesy and Cartography, Frankfort, Main, Germany.

1 (a) (i) Indeed the economists, city planners, geologists, highway engineers, architects, agriculturists, sanitary engineers and all design engineers demand topographic maps as a priority for economic development in the quickest and most economical way.

1 (a) (ii) Geodesy and Cartography, therefore must be made with modern high speed and high precision instruments and methods in order to meet the press-

ing needs of the fast growing economies of developing areas.

2. ORGANIZATION:

First and foremost it is advisable that each country establish a National Cartographic Service along organizational lines that would ensure maximum efficiency. There should be three sections of this Service, namely: Planning, data collection and examination, production and actualization; (b) Reproduction and dissemination (c) Correlation and application.

2 (a) Planning, data collection and examination, production and actualization would entail collection and grading of existing data and securing further information by application of techniques in Geodesy, Aerial Photography, Photogrammetry, Hydrography, Cartography and field checking and adapting the information to the requirements of all phases of economic development that might make use of information which could be pictorialised on maps. Among these we might include geological, soil, and forest exploration and exploitation, as well as planning and lay-out of projects for human welfare, cadastre and remembrement.

2 (a) (i) Much of the work done in this phase must be performed in air conditioned chambers and the equipment preserved in low-temperature and low humidity storage compartments. Ample travelling facilities should be provided for field crew and sufficient space for office personnel. The administrative section of this Service must be of equal efficiency as the purely technical section, so as to be of assistance in evaluating time-and-motion studies to enable production to meet the dead-line.

2 (b) Reproduction sections are always necessary adjuncts to the Cartographic Service. Preparation of photostats, enlargements, blue prints and offset prints are expected to be done in this section. For large quantities of duplications or for large-sized prints, however, it might be advisable to work in coordination with the Government printing services or with commercial printing firms.

2 (b) (i) Dissemination of information could be effected through coordination with the users directly or through sales agencies and advertising in engineering journals.

2 (c) Correlation and coordination between the activities and facilities provided by the Geodetic and Cartographic Service should be made with all organizations likely to use these facilities or to contribute pertinent data in Geodesy and Cartography. These related organizations would include the Real Estate or Cadastral Office through land registry; the Bureau of Soils, Irrigation and Reclamation; The Forestry Service; the Geological Service; the Armed Forces Mapping Service; the schools, through atlases; the Municipal Construction Services; the rural resettlement agencies; the economic planning agencies and all others so related.

2 (c) (i) One branch of the National Cartographic Service would have to be devoted to demonstration of the best possible application of maps in each type of economic development.

3. METHODS:

It is always necessary that surveys and mapping precede the economic development program. It is quite obvious, however, that in the new and emerging nations, with no mapping done already and whose rate of development is very rapid, the old classical methods of surveying and mapping are too tedious to complete the over-all mapping in time to precede or even be abreast of the economic planning program. Extensive use will therefore have to be made of Photogrammetry and of the latest electronic measuring and computing techniques. A centralised mapping office is also recommended so as to minimise the waste

due to a multiciplicity of mapping services in various agencies.

3 (a) Quite a large variety of instruments and methods are currently available. These are displayed en-masse at related international scientific conferences, notably the Congresses of Photogrammetry, Geodesy and Cartography and of the Federation International des Geometres.
3 (a) (i) While modern instruments are quicker and easier to operate, they should, however, be adapted to the nature of the task on hand. As much of the territory of developing countries is still unmapped, these countries need not hesitate to check into a vast storage of disconnected first order work already available, as would have to be done in already developed countries. A complete over-all mapping scheme would often prove more economical.

3 (b) This procedure would entail establishment of horizontal and vertical control, electronically controlled vertical aerial photography, and then photogrammetry, photo-interpretation and cartography.
3 (b) (i) In the case of hydrographic charts, these would require electronic soundings, applied to map with shore-line details. Geological, soils, vegetation and other special purpose maps would require additional ground investigation.

3 (c) One scheme for a small-scale topographic mapping of a large territory would entail locating the geographical positions of points at wide intervals by tellurometer or Mann's zenith-camera observations, applying gravimetric compensation. Vertical control could be had by running automatic levels along selected roads and connecting them with micro-barograph readings and by interpolating spot levels run to river surfaces at wide intervals. For aerial triangulation, infra-red vertical aerial photography should be taken at scale 1:70,000 with a fully automatic extra wide angle camera synchronised with Shoran or such other electronic measurements to ground control points, and with a horizon camera, an airborne profile recorder and its accessories, and with airborne geophysical prospecting equipment. Photograph coordinate points obtained by aerial triangulation could be adjusted by Yerie block adjustment methods. For very small-scale mapping stereo templets could suffice. Controlled, annotated mosaics could be made from rectified photographs.
3 (c) (i) For very large-scale mapping, which would be required for lay-out and construction projects, more precise methods would have to be employed. This would necessitate control provided by aid of precise leveling and horizontal measurement. It would require aerial photography at scale 1:25,000 followed by an accurate aerial triangulation and plotting. There is a wide range of precise instruments on the market. It is recommended that selection of the very best be made for very large scale mapping. Many instruments and methods described for use in small-scale mapping can be adapted to large-scale mapping. The high speed and accuracy with which survey and mapping can be done by use of photogrammetry with electronics makes its use indispensable. Moreover, the cost required to complete extensive projects is negligible when compared with the old classical methods.
3 (c) (ii) Contours could be drawn on maps at intervals depending on the scale required and the accuracy of the vertical aerial photography and the vertical and horizontal control. Determination of contour lines could be done either on a projection-type anaglyph or mechanical plotter or on an ordinary stereometer-mirror-stereoscope depending on the scale and contour interval required

3 (d) The several plotted sheets would have to be coordinated and projected on some central projection system: probably the Universal Transverse Mercator for small scale mapping or the Hotine's rectified skew polyconic or such other type of orthomorphic projection for large scale mapping.
3 (e) Reproduction and application phases would have to be executed with

equal efficiency.
3 (f) The need for highly trained personnel cannot be over-emphasied. Already trained personnel need specialised or refresher courses. They also need to attend related international scientific conferences and seminars in order to keep up-to-date in their techniques and instruments.

4. INSTRUMENTS:
4 (a) Geodesy: The development of the tellurometer and the geodemeter has introduced great economy in the process of triangulation and traversing and the use of these should be introduced wherever they can substitute old methods. Use of modern theodolites with glass circles would still be necessary; as would leveling instruments with compensators. Improved tachymeters as well as subtense bars, micro-barographs and improved range finders would find use in filling large gaps in the mapped area, and in actualising old maps in rapidly improving zones.
4 (a) (i) Portable gravimeters, which are too costly, would have to be rented. This condition holds also for zenith cameras, astrolabes or Gigas type theodolites with accessories for primary determination of geographical positions.

4 (b) Photogrammetry: Twin-engined aircrafts with tail-wheel landing gears are often preferred. Fully automatic aerial survey cameras, horizon cameras, as well as airborne electronic distance measuring equipment both for vertical and horizontal positioning should find increasing use. Airborne scintillometers and magnetometers should form a part of the equipment on the aerial photographic mission.
4 (b) (i) Photo-laboratories would have to be equipped with automatic rectifiers and dodging printers in addition to the standard laboratory equipment. Computing and plotting rooms would have to be equipped with electronic computers and precision projection and mechanical type triangulators and plotters. Material made of stable base would have to be provided for drawing and scribing.
4 (b) (ii) Stick-up symbols and lettering would have to be applied to the actualised map. Several projections would have to be made by rectifiers or reductions by pantographs or optical means before the finished map is sent onward for off-set printing, distribution and application.

5. AN EXAMPLE:
We in Liberia have made extensive research into our current needs in this respect. A Liberian Cartographic Service was founded in 1951, in which the United States of America played a predominant role under the U.S. "Point Four" program. The United States participation in this Service was concluded early in 1956 after four and a half years of direction involving ten (10) U.S. Coast and Geodetic Survey technicians serving in two separate groups; and visits of the top ranking staff officers of the U.S.C. & G.S. The ten-year progress report of the Liberian Cartographic Service would give a detailed account of the operation of this service. The report covers training abroad and locally of photogrammetrists, geodesists, aerial photographers, photolithographic pressmen, an aircraft pilot, laboratory technicians and hydrographers. It also covers work performed: near - first-order determination of astronomic position with Mana zenith camera, aerial photography at scales 1:40,000 on contractual basis and at larger scales by the service's own personnel and equipment. It covers establishment of vertical and horizontal control and of preparation, printing and distribution of planimetric, topographic and hydrographic maps. A more detailed account of methods used in Liberia is given in the National report on instruments and methods by J.L.F. Sawyer, to the Ninth Congress of the Federation International des Geometres. An investigation was made later by the United Nations sponsored International Training Center for

Aerial Surveys under the personal direction of Professor Dr. Ir. W. Schermerhorn of world renown. His report is available in bound volumes at the I.T.C. An excerpt from this is attached to the ten-year progress report of the L.C.S. showing the personnel, instruments and office facilities needed together with their costs. The Schermerhorn analysis lists equipment, supplies and personal for a three-year period at a cost of four hundred and sixty eight thousand ($468,000) dollars of which one hundred and eighty five thousand ($185,000) dollars is for an air-conditioned building and eighty thousand ($80,000) dollars is for a twin-engined aircraft.

5 (a) Within the last quarter, Albert Nowicki headed a team of U.S.A.I.D. technicians which made a further analysis of possibilities of resuscitation and improvement of this Service, which is so vital to the economic development of the country. The Nowicki report recommends a unified or centralised mapping Bureau which would embrace every type of mapping required for the country. In his detailed organization charts he outlines personnel distribution, grading and production flow for an outfit of 347 persons responsible for survey or data collection and mapping. The personnel are as follows: meteorological surveys - 21, hydrological surveys-10, geological surveys-30, mining surveys-14, forestry surveys-26, soils surveys-28, general mapping (in which he includes field surveys photogrammetry, manuscript ingravings and reproduction)-125, records division-11, planning division-5, logistics division-48, liberary services-6, personnel office-9, archives-2, finance-9, and headquarters-3, As the existing situation in Liberia does not combine soils and forestry surveys in the same Department with the other branches, the Nowicki analysis provides for laison facilities in case the unification cannot be achieved. He outlines a procedure whereby all useful information would be pictorialised on maps at the scales ranging between 1:250,000 and 1:50,000. This program recommends a building with the space of 53,000 square feet costing $600,000 distributed as follows: meteorology-3,000 square feet, forestry-4,000 sq. ft., water resources-2,000 sq. ft., mines-2,000 sq. ft. geology-4,400 sq. ft., mapping-21,000 sq. ft. staff and service-8160 sq. ft., Department staff-2640 sq.ft., Department headquarters-80 sq. ft., soils-3360 sq. ft. miscellaneous (stairways, etc.,)-2340 sq. ft. He recommends equipment costing $475,000 and an operations budget of $625,000. Following these pre-requisites Mr. Nowicki and his team expect a properly functioning and balanced Mapping Department capable of supplying printed large scale topographic maps of the whole country and having functional elements responsible for collecting, analysing and translating into mappable and statistical form the requirements for the economic development of the country, which would include geological, water resources, economic minerals and meteorological surveys studies and tests; and cadastral and boundary surveys, mapping and title registration.

5 (b) The Liberian Surveyors Mutual Association, now nearly eight years old, is coordinating the activities of surveyors associated with it and raising the professional standard of survey engineers in general, in terms of efficiency, integrity, salary and emoluments. The standards required by this association are comparable to universal standards and the salaries range between two hundred and fifty and eight hundred dollars for professional surveyors. Educational facilities for young surveyors are being provided by the University of Liberia, the Armed Forces Intelligence, the Bureau of Forest Conservation, the Highway Survey and Municipal Survey Sections of the Department of Public Works & Utilities, the Meteorological Service, D.P.W.U,, the Geological Service and the Liberian Cartographic Service of the Bureau of Natural Resources and Surveys, and the survey offices of several private firms operating in Liberia.

5 (c) In this program as outlined, foreign nationals play a vital role and most of the instruments are of the best foreign manufacture that our revenues can afford. Thus the emphasis has been placed on accuracy and results; which

of course, leaves the door wide open for whole hearted participation by technicians and businesses of all nationalities in the development of the cosmopolitan Republic of Liberia.

5 (d) While the above example indicates present performance and projected studies for Liberia it would serve as an index for the requirements of other developing Countries.

6. CONCLUSION:

We need not over-emphasize that it is our hope that the current program envisaged by the United Nations, with ourselves as participants, would provide an avenue for bringing Cartographic Services up-to-date. This, of course, would require a vigorous cooperation of all parties concerned. It is advisable for the United Nations Technical Assistance section to undertake pilot projects of limited duration, set up regional advisory offices and expand the program at the International Training Center for Aerial Survey, Delft, Holland.

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Paragraph 5:
"Ten-year achievement of the Liberian Cartographic Service"
Author: J. Laurence F. Sawyer. Copies available at the Liberian Bureau of Natural Resources & Surveys. Copies also in the minutes of the Tenth Congress of the Federation International des Geometres.

Paragraph 5:
"Reorganization of the Liberian Cartographic Service"
Author: Prof. D. Ir. W. Schermerhorn. Copies available at the International Training Center for Aerial Survey and at the Bureau of Natural Resources and Surveys of Liberia. A pertinent excerpt is attached to the "Ten-year achievement of the Liberian Cartographic Service."

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